

What is claimed is:

1. A lapping apparatus comprising:
 - a lapping film;
 - a film feeder configured to feed the film;
 - 5 a first drive configured to rotate a work;
 - a second drive configured to move the work relative to the film;
 - a shoe set;
 - a shoe set handler configured to handle the shoe set to press the film against the work;

and

10 a deterioration delayer configured to delay an abrasivity deterioration of the film.

2. The lapping apparatus as claimed in claim 1, wherein
the shoe set comprises a first shoe of a width, and a second shoe of the width at a
distance of the width times an integer from the first shoe, and
15 the deterioration delayer comprises a controller configured to control the film feeder to
feed the film at a distance of the width.

3. The lapping apparatus as claimed in claim 2, wherein
the shoe set comprises a number of shoes equal to the integer .

20 4. The lapping apparatus as claimed in claim 2, wherein
the shoe set comprises a first shoe set, and a second shoe set, and
the deterioration delayer comprises a detector configured to detect a condition of an
abrasive face of the film between the first shoe set and the second shoe set, and
25 the controller is configured to control the film feeder in dependence on the condition
detected by the detector.

30 5. The lapping apparatus as claimed in claim 1, wherein
the shoe set comprises a first shoe set, and a second shoe set, and
the deterioration delayer comprises a cleaner configured to clean an abrasive face of

the film between the first shoe set and the second shoe set.

6. The lapping apparatus as claimed in claim 5, wherein
the deterioration delayer comprises a film warper configured to warp the film with the
5 abrasive face outside.

7. The lapping apparatus as claimed in claim 5, wherein
the cleaner comprises an ultrasonic brush.

10 8. The lapping apparatus as claimed in claim 5, wherein
the cleaner comprises an ultrasonic bath.

9. The lapping apparatus as claimed in claim 5, wherein
the cleaner comprises a jet nozzle.

15 10. The lapping apparatus as claimed in claim 5, wherein
the film comprises a flexible and non-expansive substrate.

11. The lapping apparatus as claimed in claim 1, wherein
20 the shoe set comprises a first shoe, and a second shoe, and
the deterioration delayer comprises a first detour provider configured to provide the
film with a first detour defining a first space between the first shoe and the second shoe, and a
lubricant supplier configured to supply a lubricant to the first space.

25 12. The lapping apparatus as claimed in claim 11, wherein
the film comprises a flexible and non-expansive substrate .

13. The lapping apparatus as claimed in claim 11, wherein
the shoe set comprises a third shoe,
30 the deterioration delayer comprises a second detour provider configured to provide the

film with a second detour defining a second space between the second shoe and the third shoe, and

the lubricant supplier is configured to supply the lubricant to the second.

5 14. The lapping apparatus as claimed in claim 11, wherein
 the first detour provider comprises a tension roller configured for the first detour to
 detour therearound, and a bias element configured to bias the tension roller in a detoured
 direction of the first detour.

10 15. The lapping apparatus as claimed in claim 14, wherein
 the tension roller is rotatable.

15 16. The lapping apparatus as claimed in claim 11, wherein
 the deterioration delayer comprises a shoe case having a first support part configured
 to support the first shoe, and a second support part configured to support the second shoe, the
 first and second support parts extending in radial directions of the work defining therebetween a
 slot configured to accommodate the first detour and the first detour provider resiliently
 suspended from the shoe case.

20 17. The lapping apparatus as claimed in claim 16, wherein
 the lubricant supplier comprises a network of lubricant paths formed in the shoe case
 and communicating with the first space.

25 18. The lapping apparatus as claimed in claim 11, wherein
 the lubricant supplier is configured to deliver the lubricant from around the first detour
 provider.

30 19. The lapping apparatus as claimed in claim 1, wherein
 the deterioration delayer comprises a film oscillator configured to oscillate the film at a
 higher speed in a feed direction of the film than a rotational speed of the work.

20. The lapping apparatus as claimed in claim 19, wherein
the second drive comprises a work oscillator configured to oscillate the work relative
to the film in a direction of an axis of rotation of the work.

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21. The lapping apparatus as claimed in claim 19, wherein
the film oscillator comprises an oscillating film drawer configured with a film roller
having the film detoured therearound through the shoe set, and a radial oscillator configured to
oscillate the film roller in a first radial direction of the work, and a tensioning film drawer
10 configured with a tension roller having the film detoured therearound through the shoe set, and a
bias element configured to resiliently bias the tension roller in a second radial direction of the
work different from the first radial direction.

15 22. The lapping apparatus as claimed in claim 21, wherein
the film oscillator comprises the oscillating film drawer, another oscillating film
drawer, and tensioning film drawer disposed therebetween.

23. The lapping apparatus as claimed in claim 19, wherein
the film feeder comprises a film locker configured to lock the film at a first acting
20 point on the film, and
the film oscillator comprises a tension controller configured to control a tension of the
film at a second acting point on the film between the first acting point and the shoe set.

25 24. The lapping apparatus as claimed in claim 19, wherein
the film comprises a flexible and non-expansive substrate.

25. The lapping apparatus as claimed in claim 1, wherein
the deterioration delayer comprises a film detector configured to detect a condition of
an abrasive face of the film, and a controller configured to control one of the film feeder and the
30 shoe set handler depending on the condition detected.

26. The lapping apparatus as claimed in claim 25, wherein
the condition detected comprises a projection of an abrasive particle of the abrasive
face.

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27. The lapping apparatus as claimed in claim 25, wherein
the deterioration delayer comprises a truer configured to true the abrasive face
depending on the condition detected.

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28. The lapping apparatus as claimed in claim 25, wherein
the film detector is configured to detect the condition of the abrasive face before a
lapping service.

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29. The lapping apparatus as claimed in claim 25, wherein
the film detector is configured to detect the condition of the abrasive face after a lapping service.

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30. The lapping apparatus as claimed in claim 1, wherein
the shoe set comprises a convex shoe,
the shoe set handler comprise a shoe floater configured to float the shoe, and
the deterioration delayer comprises a controller configured to control a location of
contact between the shoe, the film, and the work.

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31. The lapping apparatus as claimed in claim 30, wherein
the controller comprises a detector configured to detect a position of the work, and a
drive configured to drive the shoe to change the location of contact depending on the position
detected.

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32. The lapping apparatus as claimed in claim 30, wherein
the floater comprise a pair of springs suspending the shoe, and
the controller is configured to control positions of the pair of springs to change a

position of the shoe.

33. The lapping apparatus as claimed in claim 32, wherein
the pair of springs have different spring constants.

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34. The lapping apparatus as claimed in claims 30, wherein
the film comprises a flexible and non-expansive substrate.

10 35. The lapping apparatus as claimed in claim 1, wherein
the deterioration delayer comprises a blocking delayer configured to delay a blocking
of the film.

15 36. A lapping apparatus comprising:
a lapping film;
film feeding means for feeding the film;
first drive means for rotating a work;
second drive means for moving the work relative to the film;
a shoe set;
shoe set handling means for handling the shoe set to press the film against the work;
20 and
deterioration delaying means for delaying an abrasivity deterioration of the film.

25 37. A lapping method comprising:
feeding a lapping film;
rotating a work;
moving the work relative to the film;
handling a shoe set to press the film against the work; and
delaying an abrasivity deterioration of the film.

30 38. The lapping method as claimed in claim 37, wherein

the shoe set comprises a first shoe of a width, and a second shoe of the width at a distance of the width times an integer from the first shoe, and

the delaying comprises controlling the film feeder to feed the film at a distance of the width.

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39. The lapping method as claimed in claim 38, wherein
the shoe set comprises a number of shoes equal to the integer.

10 40. The lapping method as claimed in claim 37, wherein
the shoe set comprises a first shoe set, and a second shoe set, and
the delaying comprises detecting a condition of an abrasive face of the film between
the first shoe set and the second shoe set, and
the controlling comprise depending on the condition detected.

15 41. The lapping method as claimed in claim 37, wherein
the shoe set comprises a first shoe set, and a second shoe set, and
the delaying comprises cleaning an abrasive face of the film between the first shoe set
and the second shoe set.

20 42. The lapping method as claimed in claim 37, wherein
the shoe set comprises a first shoe, and a second shoe, and
the delaying comprises providing the film with a detour defining a space between the
first shoe and the second shoe, and supplying a lubricant to the space.

25 43. The lapping method as claimed in claim 37, wherein
the delaying comprises oscillating the film at a higher speed in a feed direction of the
film than a rotational speed of the work.

30 44. The lapping method as claimed in claim 37, wherein
the delaying comprises detecting a condition of an abrasive face of the film, and

controlling one of feeding and handling depending on the condition detected.

45. The lapping method as claimed in claim 37, wherein
the shoe set comprises a convex shoe,
5 the handling comprise floating the shoe, and
the delaying comprises controlling a location of contact between the shoe, the film,
and the work.